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(54) **Cemented carbide body used preferably for mining abrasive rock.**

(57) The present invention relates to cemented carbide bodies preferably for wear demanding rock drilling and mineral cutting. The bodies are built up of a core of eta-phase containing cemented carbide surrounded by a surface zone free of eta-phase where the binder phase content in the outer part of said zone is lower than the nominal and, in addition, constant or near constant, and that the binder phase content in the inner part of the eta-phase free zone closer to the eta-phase core is higher than the nominal. According to the method according to the invention bodies comprising evenly distributed eta-phase are subjected to a partly carburizing treatment with a carbon activity, a_c, close to 1.

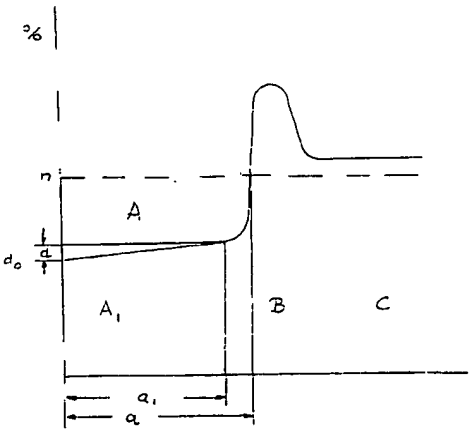

FIG 1

EP 0 500 514 A1

The present invention relates to cemented carbide bodies useful in tools for rock drilling and mineral cutting. Tools for cutting asphalt and concrete are also included.

In EP-A-182759 cemented carbide bodies are disclosed with a core of fine and ebenly distributed eta-phase embedded in the normal alpha + beta - phase structure, and a surrounding surface zone with only alpha + beta - phase. An additional condition is that in the inner part of the surface zone situated close to the core the binder phase content is higher than the nominal content of binder phase. In addition the binder phase content in the outermost part of the surface zone is lower than the nominal and increases in the direction towards the core up to a maximum situated in the zone free of eta-phase. (With nominal binder phase content is meant here and henceforth weighed-in amount of binder phase).

Cemented carbide bodies according to EP-A-182759 have shown increased performance for all cemented carbide grades normally used in rock drilling and have been a commercial success. Due to that the binder phase content increases from the outer surface towards the centre the improved wear resistance is lost relatively early. Cemented carbide bodies according to EP-A-182759 are therefore best suited for toughness demanding rock drilling operations.

High wear resistance and high penetration rate are essential properties for bits and these properties increase more and more in importance. Certain bits, in particular bits for drifting, are worn out when the diameter of the bit has decreased with 4-6 mm since the diameter of the drill hole becomes too small, thus making the blasting agent difficult to charge. Buttons in such bits are therefore seldom reground because usually the bit diameter decreases when regrinding. For these bits it is important that the buttons have a 2-3 mm thick, wear resistant zone so that the wear resistance is high and uniform during the whole life of the bit. The penetration rate depends on the shape of the button. The buttons are therefore as a rule given a shape which gives optimal penetration rate. When the shape of the button is changed by wear the penetration rate decreases successively.

It has now surprisingly turned out that it is possible to control the manufacturing process in such a way that an almost constant content of binder metal is obtained in the surface zone of the body and as a result constant hardness and wear resistance. Thereby further improvement is obtained in applications where high wear resistance is of great importance. The wear resistant surface zone in bodies according to the invention is worn more slowly than in conventional bodies and therefore a high penetration rate is maintained during long time.

Fig 1 shows schematically the binder phase distribution along a line perpendicular to the surface of a cemented carbide body according to the invention. In the figure is

- A - binder phase depleted surface zone
- A_1 - surface zone with almost constant content of binder phase
- B - binder phase rich surface zone
- C - eta-phase containing core
- n - nominal binder phase content
- d_o - binder phase content in the surface
- d - increase in binder phase content in zone A_1
- a - width of the binder phase depleted surface zone
- a_1 - width of the surface zone with almost constant binder phase content

The eta-phase free surface zone in cemented carbide bodies according to the invention is divided into two parts. In the outermost part (zone A) the binder phase content is lower than the nominal(n). In the inner part (zone B) the binder phase content is higher than the nominal. Zone A has higher hardness and stiffness due to the low binder phase content whereas zone C has higher hardness due to the finely dispersed eta-phase.

In zone A the average content of binder phase shall be 0.20 - 0.8, preferably 0.3 - 0.7 of the nominal binder phase content. The binder phase content in the outer part of zone A shall be almost constant. The relative increase or decrease in binder phase content along a line perpendicular to the surface, $d/(d_o \cdot a_1)$ shall not be greater than 20 %/mm, preferably not greater than 10 %/mm. The width, a_1, of this outer zone with constant or almost constant binder phase content shall be 50%, preferably 70%, most preferably 80% of the width, a, of zone A, however at least 1 mm. In zone B the binder phase content is higher than the nominal, and reaches a highest value of at least 1.2, preferably 1.6 - 3 of the nominal binder phase content.

Zone C shall contain at least 2 % by volume, preferably at least 5 % by volume of eta-phase but at the most 60 % by volume, preferably at the most 35 % by volume. The eta-phase shall be fine-grained with a grain size of 0.5 - 10 µm, preferably 1 - 5 µm and be evenly distributed in the matrix of the normal WC-Co-structure. The width of zone C shall be 10 - 95 %, preferably 25 - 75 % of the cross section of the cemented carbide body.

The invention can be used for all cemented carbide grades normally used for rock drilling from grades with 3 % by weight binder phase up to grades with 25 % by weight binder phase preferably with 5 - 10 % by weight binder phase for percussive drilling, 10 - 25 % by weight for rotary-crushing drilling and 6 - 13% by weight for rock cutting and where the grain size of WC can bary from 1.5 µm up to 8 µm, preferably 2 - 5 µm. It is particularly suitable for bits that are not reground, e.g. for drill bits for drifting where the bit has reached the scrap diameter

before the zone with constant binder phase content is worn away. The big difference in binder phase content, and by that thermal expansion coefficient, between zone A and the remaining zones in a button according to the invention result in high compressive stresses in the surface of the buttons which leads to extraordinary good toughness properties in parallel with the previously mentioned improvements in wear resistance compared to EP-A-182759.

In the binder-phase Co can be replaced partly or completely by Ni and/or Fe. Hereby the Co fraction in the eta-phase is partly or completely replaced by some of the metals Fe and/or Ni i.e. the eta-phase itself can contain of one or more of the iron group metals in combination. Up to 15 % by weight of tungsten in the alpha-phase can be replaced by one or more of the metallic carbide formers Ti, Zr, Hf, V, Nb, Ta, Cr and Mo.

Cemented carbide bodies according to the invention are manufactured according to powder metallurgical methods: milling, pressing and sintering. By starting from a powder with substoichiometric content of carbon an eta-phase containing cemented carbide is obtained during the sintering. This is after the sintering given a vigorously carburizing heat treatment e.g. by packing in carbon black. This means that the carbon activity, a_c, in the atmosphere of the furnace shall be close to 1, preferably at least 0.8, so that transport of carbon to the surface of the buttons during the whole heat treatment time is greater than the diffusion rate of carbon into the buttons.

Example 1

Buttons were pressed using a WC-6 weight % Co powder with 0.2 % by weight substoichiometric carbon-content (5.6 % by weight C instead of 5.8 % by weight). These were sintered at 1450°C under standard conditions. After sintering the length of the buttons was 16 mm and the diameter was 10 mm. The buttons were then packed in carbon black and heat treated in a furnace for 3 hours at 1400°C.

The buttons manufactured in this way comprised a 2 mm wide surface zone free of eta-phase and a core with a diameter of 6 mm containing finely dispersed eta-phase. The Co-content at the surface was measured to be 3 % by weight. 1.6 mm from the surface the Co-content was 3.5 % by weight and just outside the eta-phase-core 14% by weight. The width of the zone with high Co-content was about 0.4 mm.

Example 2

Rock	: Hard abrasibe granite with streaks of leptite, compressive strength 2800 - 3100 bar.
Machine	: Atlas Copco COP 1038 HD, a hydraulic machine for heavy drifter equipment. Feeding pressure 85 bar, rotation pressure 45 bar and rotation 200 rpm.
Bits	: 45 mm two-wing button bits with the periphery buttons 10 mm in diameter and 16 mm in length. 10 bits per variant were tested. The scrap diameter was 41 mm.
Cemented carbide grade	: 94 % by weight WC and 6 % by weight Co. Grain size = 2.5 µm.

Test variants

1. Buttons according to the invention comprising an eta-phase core with a diameter of 4 mm, a surface zone free of eta-phase 3 mm wide in which the low Co-content part was 2.2 mm wide.
2. Buttons comprising an eta-phase core with a diameter of 6 mm, a surface zone free of eta-phase of 2 mm with a Co-gradient according to EP-A-182759.
3. Buttons with normal structure without eta-phase.

The bits were drilled in campaignes of 7 holes, depth 5 m and were permuted in such a way that equal drilling conditions were obtained. The bits were taken out from the test as soon as the bit diameter fell below 41 mm and then the drilled meters were recorded.

Result

Variant	Life length, m		
	average	max	min
1	451	543	398
2	325	403	286
3	231	263	201

Example 3

Test drilling with 64 mm bench drilling bits were made in a quartzite quarry containing very hard quartz. Variant 1 was equipped with cemented carbide buttons according to the invention, variant 2 equipped with buttons according to EP-A-182759 and variant 3 equipped with a WC-Co-grade commonly available on the market. The buttons according to the invention as well as the buttons according to EP-A-182 759 comprised a 2.5 mm wide surface zone with low Co-content.

Test data

Drilling rig : ROC 712 with a COP 1036 machine.
Feeding pressure : 80 bar.
Impact pressure : 190 bar.
Hole depth : 12 m.
Air flushing : 5 bar.
Number of bits : 5

Result

	Regrinding interval,m	No of re-grindings	Life m	Index
1	48	3	189	145
2	36	4	157	120
3	24	5	130	100

Example 4

Test site : Iron ore mine - open pit. Drilling with roller bits.
Drilling machine : Gardner Denber GD-100.
Feeding pressure : 40 tonnes.
Rotation : 80 rpm.
Type of rock : Magnetite with streaks of quartz and slate.
Drill bit : 12 1/4" CS-2.
Variant 1 : Bit with cemented carbide buttons (chisel-shaped) according to the invention. The nominal Co-content was 10 % by weight, the button diameter was 14 mm and the length was 21 mm. Zone A was 3 mm and zone B was 2 mm.
variant 2 : Cemented carbide buttons according to prior art, with a surface zone free of eta-phase of 2.5 mm and a nominal Co-content of 10 % by weight.

Variant 3 : Cemented carbide buttons of a conventional grade with 10 % Co by weight.

Result

Variant	Life length, m	Penetration rate, m/h
1	3050	21.2
2	2583	16.3
3	1868	15.3

Claims

1. Cemented carbide body preferably for use in rock drilling and mineral cutting, comprising WC (alpha-phase) and a binder phase based on at least one of Co, Fe and Ni and comprising a core, C, of eta-phase containing cemented carbide surrounded by a surface zone, A and B, with an outer part, A, with a lower binder phase content than the nominal **characterized** in that the binder phase content in the outer part of A is almost constant and increases or decreases relatively with 20 % /mm at the most.

2. Cemented carbide body according to the preceding claim **characterized** in that the width of the eta-phase free surface zone with constant or almost constant binder phase content is at least 50 %, preferably at least 70% of the width of the whole zone A, however at least 0.8 mm.

3. Cemented carbide body according to any of the preceding claims **characterized** in that the binder phase content of the outer zone free of eta-phase is 0.2 - 0.8, preferably 0.3 - 0.7 of the the nominal binder phase content.

4. Cemented carbide body according to any of the preceding claims **characterized** in that the inner part of the zone free of eta-phase, B, has a binder phase content which is higher than the nominal.

5. Cemented carbide body according to any of the preceding claims **characterized** in that the binder phase content in zone B reaches a highest value of at least 1.2, preferably 1.6 - 3 of the nominal binder phase content.

6. Method of manufacturing a cemented carbide body according to any of the preceding claims by powder metallurgical methods such as milling, pressing and sintering whereby a powder with substoichiometric content of carbon is sintered to an eta-phase containing body which after the sintering is given a partially carburizing heat treatment whereby an eta-phase containing core surrounded by an eta-phase free surface zone is obtained **characterized** in that the carburization takes place at a carbon activity, a_c, close to 1, preferably at least 0.8.

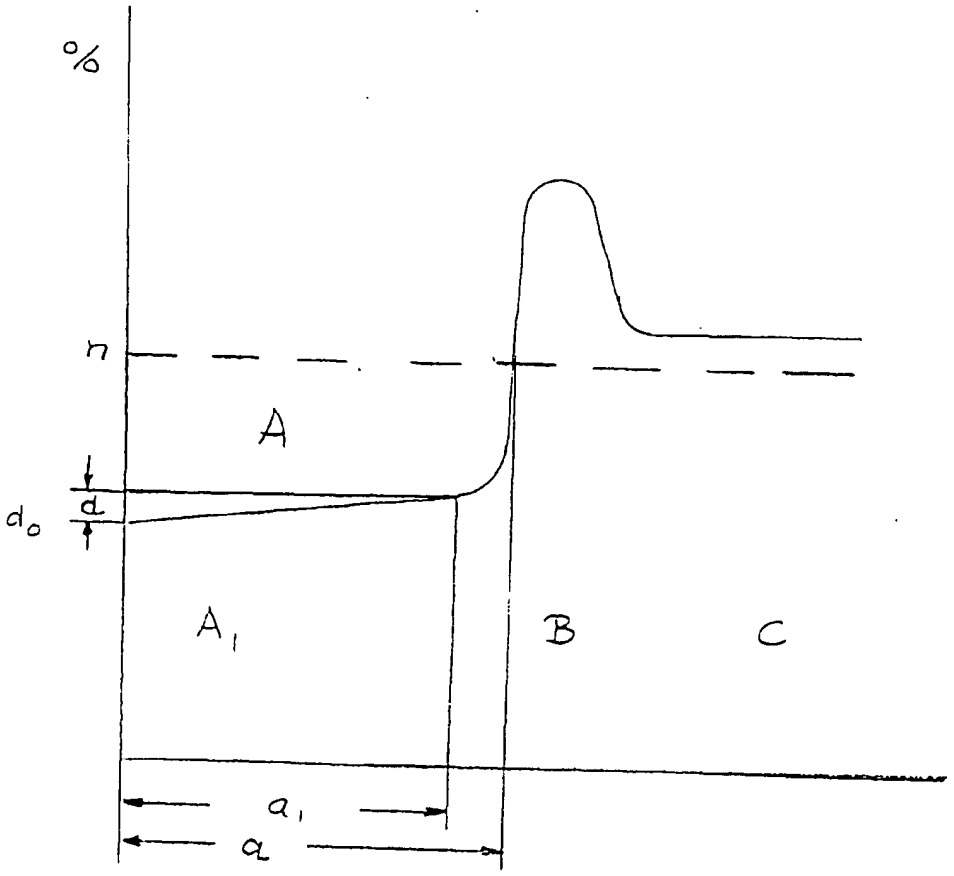

FIG 1

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 85 0035

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	DE-A-3 936 129 (MITSUBISHI METAL CORP.) * page 3, line 46 - line 53 * * page 3, line 65 - page 4, line 7 *	1,6	C22C29/08
A	EP-A-0 247 985 (SANTRADE LTD.) * page 1, line 36 - page 2, line 16; figure *	1,6	
A,D	EP-A-0 182 759 (SANTRADE LTD.) * abstract; figure 2 *	1,6	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

C22C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	06 APRIL 1992	ASHLEY G.W.

CATEGORY OF CITED DOCUMENTS

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